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WATER RESOURCES STUDY ROUND MOUND DAM AND RESERVOIR SMOKY HILL RIVER BASIN KANSAS. STUDY OF POTENTIAL NEEDS AND VALUE OF WATER STORAGE FOR QUALITY CONTROL

Public Health Service
Kansas City, Missouri

November 1963

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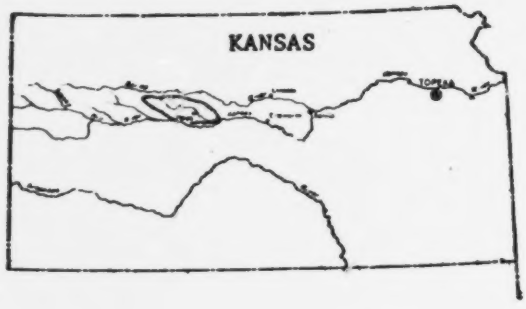
WATER RESOURCES STUDY
ROUND MOUND DAM & RESERVOIR
SMOKY HILL RIVER BASIN
KANSAS

Study of Potential Needs and Value of Water Storage for Quality Control



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Public Health Service, Region VI
Kansas City, Missouri

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To
U.S. DEPARTMENT OF INTERIOR
Bureau of Reclamation
Kansas River Projects Office - McCook, Nebraska

NOVEMBER 1963

57

WATER RESOURCES STUDY
ROUND MOUND DAM & RESERVOIR
SMOKY HILL RIVER BASIN
KANSAS

Prepared for

DEPARTMENT OF INTERIOR

Bureau of Reclamation

Kansas River Projects Office

McCook, Kansas

U. S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Public Health Service, Region VI
Kansas City, Missouri

NOVEMBER 1963

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1. INTRODUCTION

Authority

The Bureau of Reclamation, Region 7, in a letter dated July 21, 1961, requested the Public Health Service to investigate the water quality control aspects of the proposed Round Mound Reservoir.

The request was in accordance with provisions of the Federal Water Pollution Control Act, as amended by Public Law 87-88, July 1961.

Purpose and Scope

The purpose of this study is to determine the need for and value of storage for water quality control in Big Creek, a tributary of the Smoky Hill River in central Kansas.

The study covers water uses for the base period of 1960 and projected needs during the study period of 1970 to 2020, based on estimated growth and development. The study area is Ellis, Trego, and Russell Counties.

11/15/63

Acknowledgements

The cooperation of the following Federal, State and local agencies which were contacted for information and assistance is gratefully acknowledged:

1.) Kansas River Projects Office, Bureau of Reclamation, McCook, Nebraska

2.) Quality of Water Branch, U. S. Geological Survey, Topeka, Kansas

3.) City Officials, Hays, Kansas

4.) City Officials, Russell, Kansas

5.) City Officials, Ellis, Kansas

6.) Kansas Water Resources Board, Topeka, Kansas

7.) Kansas State Department of Health, Topeka, Kansas

8.) Fort Hays State College, Hays, Kansas

9.) Surface Water Branch, U. S. Geological Survey, Topeka, Kansas

10.) Ground Water Branch, U. S. Geological Survey, Kansas University, Lawrence, Kansas

11.) Kansas State Geological Survey, Department of Oil and Gas, Kansas University, Lawrence, Kansas

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II. SUMMARY AND CONCLUSIONS

Summary

1) The Round Mound Dam and Reservoir is proposed for construction by the Bureau of Reclamation on Big Creek, a tributary of the Smoky Hill River in central Kansas.

2) The primary purposes for which the reservoir is proposed are flood control, municipal and industrial water supply, and streamflow regulation for quality control in the Big Creek study area.

3) The total drainage area of Big Creek is approximately 848 square miles located in Trego, Ellis, and Russell Counties.

4) Population of the study area in 1960 was 38,901, of which 23,091 persons are living in the principal communities of Wakeeney, Ellis, Hays, and Russell.

5) Average daily 1963 water use in the area amounts to 2.7 million gallons per day, or an average per capita use of approximately 110 gallons.

6) During periods of extreme low flows, the only water flow downstream below Ellis and Hays is their sewage treatment plant effluents.

Conclusions

1) The population of the study area will increase to approximately 43,000 persons in 1970, 57,000 by the year 1995, and 77,000 people by the year 2020.

2) A dependable water supply will stimulate economic activity in Ellis, Hays, and Russell.

3) Measurable treated waste discharges that will affect the quality of receiving waters will emanate from urban areas.

4) Municipal and industrial wastes which will result from projected water use in the municipalities of [illegible], Hays, and Russell are estimated to be approximately 3.5 mgd in 1970 and 11 mgd by the year 2020.

5) Flow regulation will be required for stream water quality control

Year	Annual draft on storage required for water quality control Acre-feet
1970	420
1995	4,900
2020	12,500

6) Maintenance of [illegible] water quality in Big Creek will benefit a wide spectrum of users in the study area. Recreational opportunities, including fishing, swimming, water skiing, and boating will be increased. The esthetic values of the stream stemming from unpolluted surface water and a satisfactory public health environment will be restored and the [illegible] or preservation of property values in areas contiguous to the stream will thereby be assumed.

7) The average value of storage available for quality control is estimated at $137,000 annually for a 50-year period.

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III. DESCRIPTION OF PROJECT

Location

The Round Mound damsite is located on Big Creek, approximately 95.3 stream miles above its mouth. Ellis and Hays, Kansas, are downstream approximately 10.6 and 38.1, respectively. Russell, Kansas is approximately seven miles north of the confluence of Big Creek and the Smoky Hill River about 42 miles east of the proposed damsite.

Cedar Bluff Reservoir is on the Smoky Hill River approximately 10 miles south of the Round Mound damsite. Wilson Reservoir is on the Saline River approximately 70 miles east of the Round Mound damsite. See Map of Area in Section IV.

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The Ogallah gaging station is located on Big Creek 10 stream miles above the damsite. During the period of available record in October 1955 to September 1960, periods of no flow were reported in three of the years. The maximum flow reported is 18,500 cubic feet per second (cfs) and 34.3 cfs is the average flow for the period of record.

The Hays gaging station is located on Big Creek 38 stream miles below the damsite. During the 15 years of record the flow has varied from 0 to a maximum flow of 22,400 cfs, with an average flow of 54.8 cfs. Discharges for this station are at times estimated on basis of weather records and records for stations near Ogallah on Big Creek and near Russell on the Saline River.

Water Quality

Data available from the U. S. Geological Survey indicate the following mineral concentrations in the water of Big Creek at the Ogallah gaging station for the period of record (1956, 1957 and 1958 water years).

Concentrations in Parts per Million (ppm) 1/

Constituent	Maximum	Minimum	Weighted Averages
Dissolved Solids	372	122	163
Hardness ($CaCO_3$)	282	72	110
Chlorides (Cl)	16	.0	1.3
Sulfates (SO_4)	36	1.0	7.3
Nitrates (NO_3)	8.4	.0	6.0

Corresponding flows ranged from a high of 6,720 cfs to a low of 0.23 cfs, with both extreme flows occurring in the 1957 water year.

The maximum concentrations listed are well below, the limits not to be exceeded, standards of quality for drinking water sources. The maximum nitrate is high for surface waters and may contribute to algae troubles in the reservoir.

Pertinent Data

As proposed, the Round Mound Dam will control a drainage area of 332 square miles, which is approximately 39 percent of the Big Creek Basin.

Storage space data for the proposed reservoir at 100 year conditions are shown below in acre-feet: 2/

Flood Control	107,000
Conservation	58,000
Inactive & sediment	10,600
TOTAL	175,600

Feasibility studies by the Bureau of Reclamation show that a conservation pool of 58,000 acre-feet is the largest feasible at the Big Creek site.

IV. DESCRIPTION OF STUDY AREA

Location and Boundaries

The Big Creek Basin is located between the Saline River Basin and the Smoky Hill River Basin in central Kansas. The total drainage area is approximately 848 square miles. The basin is a rough ellipsoid of approximately 75 miles by 10 to 15 miles, with the long axis roughly parallel to the course of the Smoky Hill and Saline Rivers. See Map of Area in Section IX.

The study area is defined as those portions of Trego, Ellis, and Russell Counties which lie in the Big Creek Basin. The principal municipalities in the study area are Ellis, Hays, Russell, and Wakeeney. Russell, Kansas is adjacent to the watershed.

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Geography [1/]

The Saline and Smoky Hill Rivers flow from west to east across Trego, Ellis and Russell Counties.

Big Creek flows in a southeasterly direction across central Ellis County and joins the Smoky Hill River in southwestern Russell County.

The valleys of the larger streams are relatively flat and vary in width from less than a mile to several miles. They are bordered in some places by terraces sloping toward the valleys that are dissected by short tributary streams. Gentle to steep slopes separate the valleys from the upland surface.

The uplands over most of the area are formed by the Carlile shale, which has produced a relatively flat surface having an eastward slope.

The gentle slope of the surface of the Carlile shale is broken north and west of Hays by a prominent escarpment produced by the resistant chalk beds in the Niobrara formation.

The greater part of the City of Hays is located in the valley of Big Creek. The valley upstream from Hays is about 1 to 1.5 miles wide. Big Creek is a meandering stream that occupies the northeast side of its valley above Hays. A short distance below Hays the valley narrows abruptly to a width of 0.5 to 0.8 of a mile with the stream cutting against a southwest bluff, leaving most of the valley plain northeast of the stream. The valley floor in the vicinity of Hays is in most places relatively smooth, with a gradual slope toward Big Creek.

Big Creek Valley in the Hays area is bordered on both sides by terraces. The terrace along the north side of the valley ranges from less than one mile to about two miles in width and has a southward-sloping surface that has been dissected by many tributaries of Big Creek. The divided areas between the tributaries are at approximately the same height, and when viewed from a distance they appear to form a nearly level surface. The southeast edge of this terrace is only about 20 feet above the present floor of Big Creek Valley, whereas the north,or outer edge, is about 80 feet above the valley floor.

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Climate

Kansas has a continental-type climate characterized by hot summers and moderately cold winters. 5/ In the Smoky Hill River Basin, climatic

conditions range from humid in the east to semi-arid in the west, with the Big Creek Basin falling approximately in the center.

The Big Creek Basin receives an average of approximately 20 inches of precipitation in the extreme west and about 24 inches in the extreme east. Average annual temperatures are about 54° F., with wide variation in the day-to-day and year-to-year extremes. The average January temperature at Hays is about 29° F. and the average July temperature is about 79° F. 4/ The average growing season is approximately 170 days.

Principal Communities and Industries

Wakeeney (1960 population 2,901) is about 13.5 miles northwest of the damsite on Ogallah Creek which joins Big Creek below the damsite. Wakeeney, Ellis, Hays and Russell, Kansas are four principal communities in the Big Creek study area.

Hays (1960 population 11,947) is known today as an agricultural and educational community with interests in oil and livestock. One of the largest dry land farming experiment stations in the world is located here, as are Fort Hays, Kansas State College and St. Joseph Military Academy.

Russell (1960 population 6,113) is the second largest community in the study area. Russell, the county seat of Russell County, is a trading center for the nearby oil, wheat and cattle producing areas.

Ellis (1960 population 2,218) is approximately 10 miles downstream from the proposed damsite.

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V. ECONOMICS

The Present

Economic investigations were made for Ellis, Trego and Russell Counties. Services, agriculture, mining, and manufacturing, in that order of importance, support the economy of the study area.

In 1960, 66 percent of the labor force (14,421) was employed in the service category. Approximately 40 percent of this category was employed in the educational, medical, and cultural facilities in the city of Hays. 6/ See Table No. V-1 for employment trends.

Table No. V-1

The Number and Percentage of the Labor Force 6/

by Major Classification in the Round Mound Study Area

1940 - 1950 - 1960

	1940		1950		1960	
	Number	Percent of Labor Force	Number	Percent of Labor Force	Number	Percent of Labor Force
Farm	4,102	33	3,892	28	2,807	19
Mining	1,187	9	1,579	11	1,092	8
Manufacturing	248	2	369	3	585	4
TOTAL BASIC	5,537	44	5,840	42	4,484	31
TOTAL SERVICE	6,209	49	7,875	56	9,543	66
UNEMPLOYED	894	7	351	2	394	3
TOTAL LABOR FORCE	12,640	100	14,066	100	14,421	100

Agricultural employment has decreased from 4,102 in 1940 to 2,807 in 1960. 6/ The number of farms has also had a gradual decrease from 2,904 in 1949 to 2,465 in 1959; 7/ however, the value of farm products sold

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has had an 86 percent increase during this period. [7] This is the general trend of the nation; that is, with farm consolidation and improved farming methods, agricultural production increases with less workers and farms. See Table No. V-2 for agricultural trends.

Table No. V-2

Agricultural Trends [7]

Round Mound Study Area

	Number of Farms	Cropland Harvested (acres)	Value of all Farm Products Sold (dollars)*
1949	2,904	648,310	14,275,541
1954	2,802	614,350	21,686,830
1959	2,465	546,294	26,778,812

* Adjusted to the 1954 value of the dollar

Minerals of commercial value extracted in the study area are petroleum and sand and gravel.

In 1960, the State of Kansas produced over 113 million barrels of oil; Ellis County was the leading county, with over 11 million barrels. Russell County is also a leading petroleum producer with over 8 million barrels produced in 1960. This crude petroleum is transferred out of the area by pipeline and truck. The value of minerals extracted has decreased slightly between 1953 and 1960. A gradual production decrease in Russell County and a general decrease in crude oil prices has been responsible for this situation. Table No. V-3 depicts the value of minerals extracted from 1953 to 1960. [12]

Table No. V-3

Values of Minerals Extracted 8/

Round Mound Study Area

1953 - 1960
(millions dollars*)

	1953	1954	1955	1956	1957	1958	1959	1960
Study Area	65.8	66.6	64.4	64.1	63.7	62.2	60.0	58.6

* Adjusted to the 1954 value of the dollar

Manufacturing has played a minor role in contributing to the economy of the area. In 1960, four percent of the labor force was employed in this category. Employment in manufacturing has shown a gradual numerical increase from 248 in 1940 to 588 in 1960, with 50 percent of the employment in the food and kindred products industries. Growth in this manufacturing category is also reflected by the increase in the number of establishments (from 21 in 1947 to 32 in 1958). Value added by manufacturers has increased from $1.5 million in 1954 to $2.1 million in 1958 (adjusted to the 1954 value of the dollar). See Table No. V-4.

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Table No. V-4

Manufacturing Trends 9/

Round Mound Study Area

1947 - 1954 - 1958

	Establishments	Value Added by Manufacturers ($1,000*)	Capital Expenditures ($1,000*)
1947	21	**	**
1954	26	1,508	107
1958	32	2,055	339

*Adjusted to the 1954 value of the dollar

**Data unavailable

The population of the study area has increased approximately 25 percent since 1910. The urban portion (2,500 or more) had a dynamic increase from no urban population in 1910 to 20,868 in 1960, while the rural segment decreased from 28,368 in 1910 to 17,223 in 1960. Table No. V-5 depicts population data for the study area. The city of Hays has shown the most significant increase from a population of 1,961 in 1910 to 11,947 in 1960. 10/

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Table No. V-5

Population Data [10]

Round Mound Study Area

1910 - 1960

	1910	1920	1930	1940	1950	1960
Urban *	-	3,165	4,618	11,201	17,757	20,868
(Ellis)	(1,404)	(1,876)	(1,957)	(2,042)	(2,649)	(2,218)
(Hays)	(1,961)	(3,165)	(4,618)	(6,382)	(8,625)	(11,947)
(Russell)	(1,692)	(1,700)	(2,352)	(4,819)	(6,483)	(6,113)
(Wakeeney)	(885)	(1,003)	(1,408)	(1,852)	(2,446)	(2,808)
Rural	28,368	27,601	28,804	25,593	20,560	17,223
Total	28,368	30,766	33,422	36,794	38,317	38,091

* Bureau of Census definition (2,500 or more)

The Future

The creation of a dependable water supply by construction of Round Mound Dam is expected to stimulate the economic activity of Ellis, Hays and Russell.

Services are expected to continue to be the dominant segment of the labor force. Increased enrollment in the Fort Hays College is expected to contribute largely to this category.

Agricultural employment is expected to decrease from 2,807 in 1960 to 2,200 in 2020. However, a continual improvement of farming methods should result in production increases.

Mining employment is expected to remain relatively stable. The study area should continue to maintain its high rate of crude oil extraction over the next 30 years. Then secondary recovery and more explorations in the petroleum fields are expected.

Manufacturing employment is expected to have a sharp increase from 585 in 1960 to about 5,600 by the year 2020; the food and kindred products segment should continue to employ the largest number. Other segments which should have employment increases are fabricating metals, other durables, textile and apparel, and printing and publishing.

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Table No. V-6

Projected Employment of Labor Force

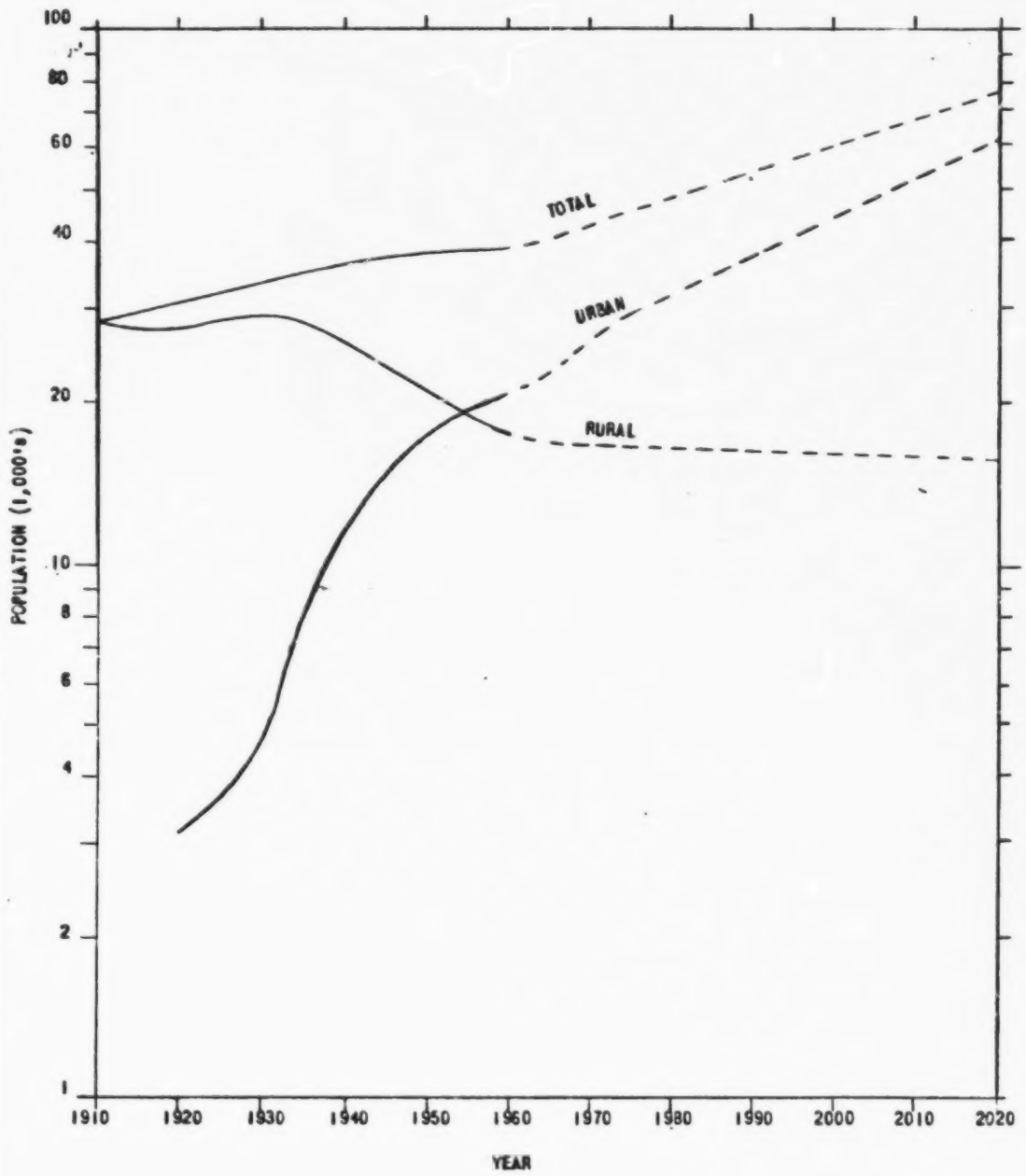
Round Mound Study Area

1970 - 2020

	1970		2020	
	Number	Percent of Labor Force	Number	Percent of Labor Force
Farm	2,700	16	2,200	8
Mining	1,100	7	1,200	4
Manufacturing	1,200	8	5,600	19
TOTAL BASIC	5,000	31	9,000	31
TOTAL SERVICE	11,000	66	19,000	66
UNEMPLOYED	500	3	800	3
TOTAL LABOR FORCE	16,500	100	28,800	100

The population of Kansas is expected to reach approximately 3,500,000 by the year 2000 and, assuming that this growth rate continues, approximately 4,500,000 by 2020. 11/

The study area is expected to increase at the same rate as the State, and reach a population of 77,000 by the year 2020. Of this total, 62,000 is expected to be urban and 15,000 rural. Figure No V-1 displays population projections for the study area.



ROUND MOUND STUDY AREA

POPULATION
TRENDS & PROJECTIONS

U.S. DEPARTMENT OF HEALTH, EDUCATION & WELFARE
PUBLIC HEALTH SERVICE
REGION VI KANSAS CITY

Figure No. V-1

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VI. HYDROLOGY

Surface Water

The total drainage area of Big Creek is approximately 848 square miles. The drainage area at Hays is about 542 square miles and at the proposed damsite 332 square miles. Conditions at the Ogallah gaging station (drainage area 297 square miles) correspond closely to the expected inflow conditions at the damsite. Historical streamflow records for the two gaging stations on Big Creek are presented below.

Table No. VI-1

Historical Streamflows

Round Mound Study Area

Station	Location	River Miles*	Years of Record	Flows in cfs Maximum	Minimum	Average
Big Creek near Ogallah, Kansas	10 miles west of Ellis	BC-82	5	18,500	0	33.9
Big Creek near Hays, Kansas	3 miles southeast of Hays	BC-49	14	22,400	0	54.2

*River miles are approximate

The mineral quality of the water in the proposed reservoir was estimated by using known mineral concentrations at the Ogallah Gaging Station and past rainfall records. The mineral qualities used were those for water years 1955-56, 1956-57, and 1957-58.

Table No. VI-2

Mineral Concentration in Water Samples from

Big Creek-Ogallah Gaging Station

Round Mound Study Area

Water Year October to September	Average Flows cfs	Mineral Concentrations (parts per million - ppm*)				
		NO_3	SO_4	Cl	T.D.S.	Hardness
1955-56	2.27	3.6	7.3	3.3	219	153
1956-57	99.8	6.5	5.8	0.8	153	102
1957-58	22.8	3.9	14	3.5	199	138
Weighted averages**		6.0	7.3	1.3	163	110

* Averages composited by discharge method from Geological Survey Quality of Surface Water records.

** Weighted averages for water years 1955-56, 1956-57, and 1957-58.

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With the losses due to evaporation, which will occur during extended dry periods and with no inflow to the reservoir, the maximum mineral concentrations in the water of the reservoir may increase to about three times the average mineral concentration of the inflows. Using these assumptions, the following maximum mineral concentrations could occur in the reservoir:

SO_4	-	21.9 ppm
Cl	-	3.9 ppm
T.D.S.	-	489 ppm
Hardness	-	330 ppm

During reservoir operations, the water releases, except during extended periods of drouth, will be diluted and the quality improved by stream inflows. It is expected that during a high percentage of time the quality of water reaching the municipalities downstream will be well below the maximum allowable concentration limits of the Public Health Service requirement for drinking water sources.

The average nitrate concentrations are in a range of 3.6 to 6.5 as NO_3. When converted to nitrogen as "N" the range is .8 to 1.5 ppm. If algae troubles are to be prevented in the reservoir, the level of concentration of available nitrogen should be less than 1.0 ppm as "N". 22/ Greater concentrations may cause algal bloom resulting in taste and odor problems in the municipal water supplies.

The estimated buildup in hardness due to evaporation losses in the reservoir would limit the usefulness of the water for municipal and industrial use unless the hardness was reduced by treatment.

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Ground Water [4,5,13]

A brief description of each of the major aquifers underlying the Round Mound study area is contained in this section. In general, the study area is underlain by rocks of the Cretaceous age with patches of Tertiary deposits overlying the Cretaceous rocks in some upland areas, and materials of Quaternary age occur in the stream valleys.

Cretaceous Rocks - Rocks of Cretaceous age crop out or underlie the surface at shallow depths over the entire area under consideration. Cheyenne Sandstone - Water from the Cheyenne sandstone, for the most part highly mineralized, is not used in this area for domestic or municipal water supplies, and has been pumped at only a few places for a water supply for drilling oil wells. This sandstone has been approved by the Kansas State Department of Health as a disposal horizon for oil field brines. Kiowa Shale - The Kiowa shale, which consists of shale, silt and fine-grained sandstone, is a poor waterbearing formation. So far as is known, no wells in this area obtain water from this formation. Dakota Formation - The Dakota formation consists dominantly of clay, shale, and siltstone containing beds of fine-grained sandstone and an interlacing network of channel sandstones. In Russell County many domestic and stock wells obtain water from one or more of the sandstones in the Dakota formation. The quality of water obtainable from these various sandstone lenses is quite variable (see Exhibit No. 3); some wells yield water of usable quality, whereas water from other wells is too highly mineralized to be suitable for most uses. Graneros Shale - The Graneros shale consists dominantly of shale, hence it generally yields little or no water to wells. In some localities where the

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formation is sandy, it yields meager supplies of water of poor quality.

Greenhorn Limestone - At some localities in Russell County, water for domestic and stock use is obtained from the near-surface weathered part of the Greenhorn limestone. Shallow wells dug with a relatively large diameter to afford maximum collecting and storage capacity yield only limited supplies.

Carlile Shale - A few shallow dug wells obtain meager supplies of water from the weathered near-surface part of the shale and mantlerock; this is not a good waterbearing formation. Wells in the Codell sandstone member of the formation may yield as much as 10 gallons per minute and provide some water for domestic and stock use. Niobrara Formation - A quantity of water sufficient for domestic and stock use cannot generally be obtained from the chalk or chalky limestone of the Niobrara formation.

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Tertiary Rocks - Deposits of Tertiary age are spread over the upland areas of much of northern Ellis County, and discontinuous areas of tertiary deposits occur on the divides in western and central Russell County.

Ogallala Formation - In these areas where an appreciable thickness of tertiary sand or gravel occurs, supplies of ground water generally have been found to be adequate for domestic and stock needs. Many wells in the area north of Gorham in west-central Russell County obtain water from tertiary sand and gravel. A large well was drilled during 1941 into this formation to obtain a water supply for the city of Gorham. See Exhibit No. 3 for data on this water.

Pleistocene Deposits - Many wells obtain water for domestic and stock use from the sand and gravel deposits of the Pleistocene Terrace deposits,

particularly along the valleys of Big Creek, Smoky Hill, and Saline Rivers. It is possible that wells yielding as much as several hundred gallons per minute could be developed in a few places where the terrace gravels attain maximum thickness. The quality of water obtained from the Pleistocene deposits is satisfactory for most uses except in areas where this shallow ground water has been polluted by brine from disposal ponds, improperly cased wells, or seepage from polluted Cretaceous sandstones.

Recent Alluvium - Wells yielding as much as 500 gallons per minute might be developed at the most favorable sites in the alluvium of the major valleys. In many places water migrates from adjacent Tertiary and Cretaceous deposits into the alluvium, so the water quality varies. In some samples analyzed the hardness was recorded as high as 1,147 parts per million, and the total dissolved solids as high as 1,728 parts per million.

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The typical water analyses of water resources, as shown in Exhibit No. 2, reveal that the hardness concentrations of the ground water supplies are high. The seven water analyses of ground water show the hardness concentrations in a range of 230 to 550 parts per million (ppm). The hardness is undesirable for both domestic and industrial uses.

VII. WATER REQUIREMENTS

Present Water Use

At present there are seven communities with municipal water facilities in the Round Mound Study Area. A discussion of each water supply follows, and a summary of water supply data appears in Exhibit No. 1. The average daily water use by the seven communities amounts to 2.7 mgd (million gallons per day). The 1963 population served was 24,225, and the average per capita use was approximately 110 gallons per day.

Collyer (1960 population 233) is located in Big Creek Basin on the western edge of Trego County. The municipal supply of this community is furnished from a single deep well. Mineral analysis (see Exhibit No. 1) indicates that the water is of acceptable quality for domestic consumption. 14/

10/11/63

Wakeeney (1960 population 2,808) is located on Ogallah Creek approximately 13.5 miles northwest of the Round Mound Damsite. Available data indicate Wakeeney has five wells in two separate well fields, tapping both the recent alluvium of Big Creek and the tertiary sand and gravel deposits on the terrace above Big Creek.

Ellis (1960 population 2,218) is located on Big Creek approximately 10 miles downstream from the proposed Round Mound Damsite. Ellis presently obtains its water supply from eight wells in the Big Creek alluvium near the city. Recharge to these wells is mainly from channel storage provided by a diversion dam on Big Creek at Ellis. 5/

It is estimated [14] that the yield of the alluvium in the area around Ellis is limited to approximately 0.35 mgd. Exhibit No. 2 gives the available mineral quality information on these wells. Although the water is moderately high in total solids and hardness its mineral quality is generally within the acceptable limits of the Public Health Service Drinking Water Standards of 1962.

Hays (1960 population 11,947) is located on Big Creek approximately 30 miles below the proposed damsite. In 1944 Hays developed another source of supply from wells approximately 10 miles south in the valley of the Smoky Hill River. Wells were installed, together with a pumping plant, pipeline, and water treatment plant. The estimated cost of the water treatment plant was about $320,000. The total cost of the entire installation was about three-quarters of a million dollars. The community developed three additional wells along the Smoky Hill River in 1957 and two additional wells along Big Creek in 1958. The present well system includes eight wells along Big Creek and six wells along the Smoky Hill River.

Victoria (1960 population 1,170) is located on Victoria Creek about five miles above its mouth and nine miles east of Hays. Victoria presently has 10 wells in two well fields tapping the terrace deposits and alluvium of Victoria Creek and also the alluvium of Big Creek. At the present time approximately half (0.08 mgd [15]) of the municipal water use in Victoria is supplied by the city wells on Big Creek.

Gorham (1960 population 429) is located in the uplands approximately 15 miles east of Hays and five miles north of Big Creek. The municipal water supply for Gorham is derived from a well in the Ogallala formation. 13/ The typical chemical analysis of water from this well (Exhibit No. 2) shows the total solids and hardness to be higher than is desirable in a municipal supply, but not enough to render the water unfit for use for this purpose. However, high nitrate concentrations (excess of the 45 mg/l allowable limit of the Public Health Service Drinking Water Standards) make it undesirable for use in infant feeding. Concentrations of nitrate above this level have caused methemoglobinemia (nitrate poisoning) in infants.

10/11/63

Russell (1960 population 6,113) is located approximately 25 miles east and two miles north of Hays in the uplands area. In the past, meeting the municipal water supply demand for Russell has probably been the most difficult water supply problem in the study area, 5/ due to the extensive costs of developing a dependable water supply. Russell now obtains water from Big Creek and the Smoky Hill River. Russell and the Bureau of Reclamation have made a long term contract for water supply from Cedar Bluff reservoir. Since the drouth of the 1950's the city has pumped only small amounts of water from the Smoky Hill River to keep the pumping plants in condition.

The 1952-1957 drouth period caused a critical water supply shortage for many of the cities located in the eastern portion of the Smoky Hill River Basin. According to the State Department of Health 5/, four communities

(Victoria, Gorham, Russell and Hays) in the Big Creek Basin were short of water in 1954. With the exception of Hays these shortages were the result of inadequacies in the source of supply. Hays indicated that its source of supply was adequate but that an inadequate distribution system caused a water shortage. Although Ellis did not have a water supply shortage in 1954, its supply was inadequate to meet the demands in 1952 and 1955.

Future Water Needs

As discussed previously, the main water supply problems in the study area concern the municipalities of Ellis, Hays and Russell. It is assumed that Ellis and Hays will continue to use their ground sources of municipal water supply. It is expected that the future needs of the remaining municipalities in the study area can be met by proper expansion of existing sources of supply. 5/

Projections of the population of the study area to the year 2020 indicate that the combined populations of Ellis, Hays and Russell will be more than 60,000. Available water use data 5,14,15,16,17/ indicate that the water use for these three municipalities is approximately 110 gallons per capita per day. Projections to the year 2020, assuming a dependable water source, estimate an average water use of 180 gallons per capita per day.

It is estimated that the total municipal water demand of Ellis, Hays, and Russell in year 2020 will be approximately 11 million gallons per day. Return flows from Ellis and Hays are expected to continue to discharge to

Big Creek, and would be available for re-use downstream. Therefore, through re-use of water downstream, approximately nine mgd, or 10,000 acre-feet of water per year, will be required to meet the 11 mgd municipal and industrial needs of Ellis, Hays and Russell, unless, to meet future municipal and industrial water needs, it is necessary to pipe water directly from the reservoir. Considerations should be made for making provisions for taking water directly from the reservoir in the future for downstream municipal use.

VIII. STREAMFLOW REGULATION FOR QUALITY CONTROL

Present

Sewage treatment plant effluents from Wakeeney, Ellis, Hays, Victoria, and Gorham discharged into Big Creek contain an organic residue equivalent to the normal sewage of approximately 3,400 persons from a tributary population of about 17,000 persons. Basic data on present sources of pollution in the study area are presented in Exhibit No. 3.

Inorganic pollution, notably chlorides and dissolved solids, enters the stream from highly mineralized aquifers contributing to streamflow. There is some additional buildup from municipal waste discharges. These inorganic pollutants are expected to be well below the maximum allowable concentration limits of the Public Health Service requirements for drinking water sources a high percentage of the time.

Future

Prospective waste loadings to Big Creek below the proposed reservoir have been estimated on the basis of population and industrial growth projections. The main factors used in estimating the future pollution loads in Big Creek are Shown in Table No. VIII-1.

Table No. VIII-1

Waste Loading Projection Factors

Round Mound Study Area

Factor	1970	1995	2020
Municipal Sewage Plant Loads for Ellis & Hays (P.E./Day Raw)	14,000	31,000	55,000
Municipal Water Demand, GPCD	140	160	180
Municipal Return (Percent)	85	85	85
Organic Load per Capita (Pounds 5-day BOD)	0.17	0.17	0.17
BOD removal efficiency (Percent)	85	85	85

The pollutional effects of waste discharged to a receiving watercourse are a function of a number of variables. Assumptions used in estimating the needs for quality control storage in the Round Mound study area are enumerated below:

1) Waste discharges to the stream will continue to be primarily organic in nature.

2) Considering the needs for water and the costs of providing this water, it was decided that a degree of protection of 90 percent, represented by a 10 percent probability of flows being equal to or less than those provided for, would be reasonable for this area.

3) Maintenance of a 5 mg/l level of dissolved oxygen in accordance with the objectives of the Missouri Basin Engineering Health Council.

4) The three different annual water temperature periods are: Summer, four months long with an average water temperature of 22°C, spring and fall, three months long and a water temperature of 12°C; and winter, five months long and a water temperature of 2°C.

Hays is the critical point in the basin as far as pollutional loading is concerned. Table No. VIII-2 shows the total flow needed at Hays. The effects of upstream waste discharges have been considered in making the estimates.

Table No. VIII-2

Summary of Total Water Quality Needs at Hays
(flow in mgd)

Round Mound Study Area

1970			1995			2020		
Spring & Fall	Winter	Summer	Spring & Fall	Winter	Summer	Spring & Fall	Winter	Summer
2	2	6	4	3	14	10	6	24

Estimates based on a study of monthly runoff patterns at Big Creek gaging station near Hays indicate that the following uncontrolled runoff in mgd with a probability of recurrence of 10% could be expected under natural low-flow conditions at Hays.

	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.
Without proposed reservoir (drainage area - 540 sq. mi.)	2.3	6.7	6.7	4.7	4.7	3.1	2.1	1.7	1.5	1.1	1.4	2.0
With proposed reservoir (drainage area - 210 sq. mi.)	0.9	4.6	4.6	1.8	1.8	1.2	0.8	0.7	0.6	0.4	0.6	0.8

Considering quality control needs, natural runoff, municipal returns, and seepage, Table No. VIII-3 lists the annual draft on storage needed to maintain the quality objective in the stream.*

Table No. VIII-3

Summary of Net Annual Regulation Requirements in Acre-Feet

Round Mound Study Area

Protection Level (%)	Year of Development 1970	1995	2020
90	420	4,900	12,500
70	0	380	7,500
50	0	0	1,220

*Figure No. VIII-2 shows this trend graphically Exhibit No. 4 gives sample monthly reservoir releases needed to maintain the quality requirements of the stream.

The largest organic loading in Big Creek is at Hays, Kansas, and the greatest need for quality control water will be from Hays downstream to Russell. The water for quality control requirements is based on the needs due to organic discharges to Big Creek. During times of heavy well pumping for water at Hays, the inorganic content of effluents discharged to Big Creek will be higher than when using only Big Creek water.

Due to the expected varying inorganic content and the increase in organic loading, it is recommended that a surveillance program be initiated during operation of the reservoir. This is expected to result in a more economical use of water releases for quality control from Round Mound Reservoir with better maintenance of water quality.

As the organic loading in Big Creek increases, it may become necessary to chlorinate the sewage plant effluents in order to protect the water users downstream.

Value of Storage

The following sources were considered in estimating the value of storage in Round Mound Reservoir for quality control in Big Creek:

1) Ground water pumping

2) Single-purpose reservoir on the Round Mound site

3) Single-purpose reservoir on Ogallah Creek

4) Single-purpose reservoir on Ogallah Creek with diversion from the Saline River.

5) Re-allocation of storage in Cedar Bluff Reservoir with conveyance to Big Creek

The ultimate yield of ground water in the study area is insufficient to meet present municipal needs and this alternative is eliminated from further consideration.

The second alternative, a single-purpose reservoir at the Round Mound site, would provide water for quality control. A preliminary cost estimate [17] for this single-purpose dam and reservoir indicates the total construction cost would be $14,800,000. The operation and maintenance costs would amount to $12,000 annually, which would be in addition to the construction cost.

The third alternative, a single-purpose reservoir on Ogallah Creek would yield only 600 acre-feet/year. [17] Due to the low yield this reservoir has been dropped from further consideration.

The fourth alternative provides for construction of a single-purpose reservoir on Ogallah Creek and construction of a diversion dam and canal to divert flows from the Saline River into Ogallah Creek to provide the volume required for quality control. A preliminary cost

estimate for this alternative [17] indicates the total construction cost would be $9,950,000. The operation and maintenance costs of about $16,000 would be in addition to this construction cost.

The fifth and most feasible alternative considered would be to purchase the Federal fish hatchery below Cedar Bluff Dam and re-allocate the 4,000 acre-feet per year from Cedar Bluff Reservoir from fish hatchery use to water for quality control. Also, a surface diversion structure would be needed on the Smoky Hill River and necessary pipeline and pumping facilities to pump the water into Big Creek.

The estimated cost of this system is $2,433,000. This includes purchasing the fish hatchery, the allocated share of Cedar Bluff Dam and Reservoir investment, and pumping system. The cost of water per acre-foot would vary with the amount pumped due to the amount of power used, although the fixed cost would remain essentially the same.

A summary of the cost of this alternative is shown in Table No. VIII-4.

Table No. VIII-4

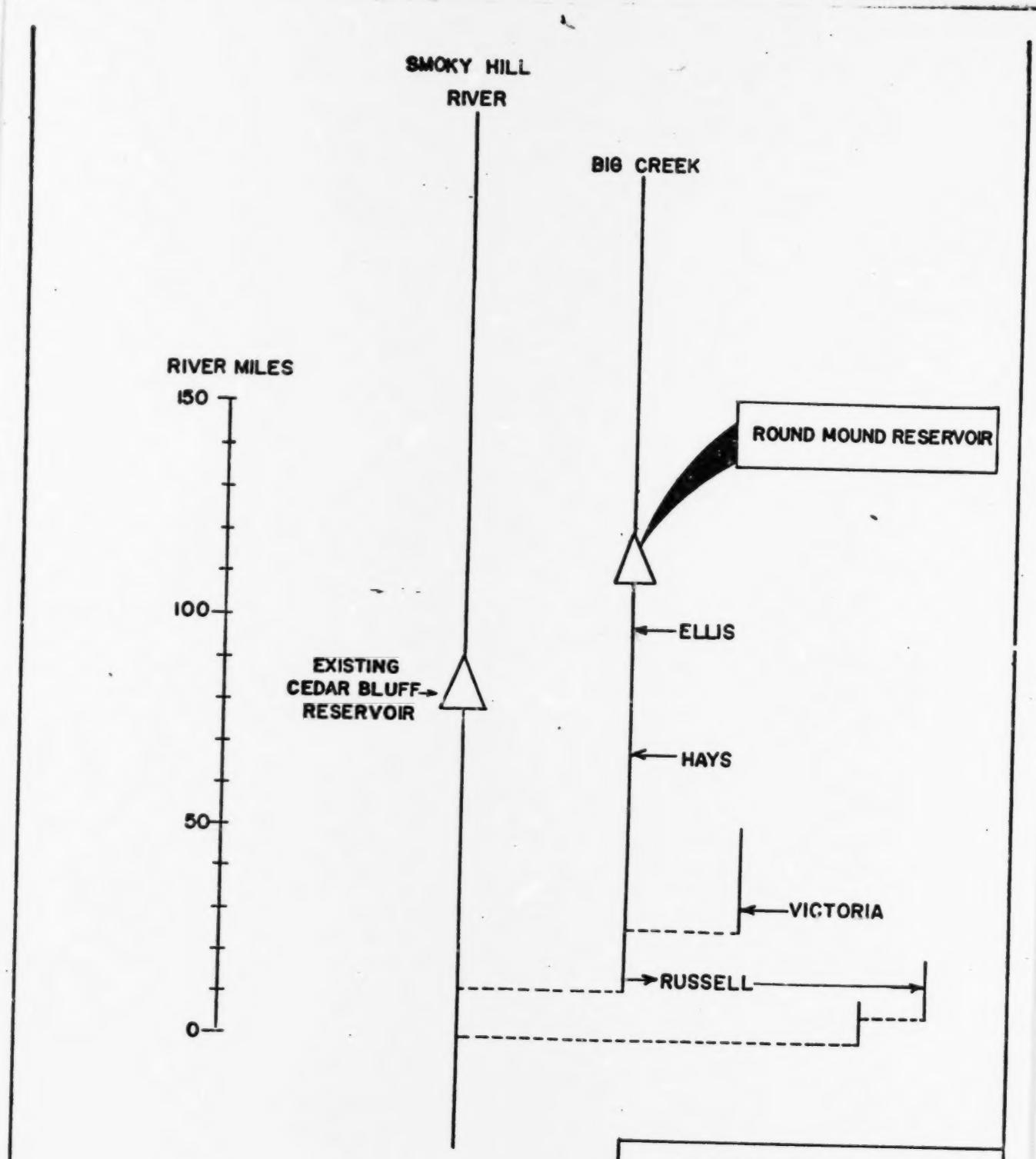
Cost Analyses of Quality Control Alternative
Round Mound Study Area

Fish Hatchery		
Buildings and equipment	$ 367,000	
Water Supply	662,500	$1,029,500
Pumping System, Smoky Hill to Big Creek		1,403,500
TOTAL first cost		$2,433,000
Annual O&M		
Replacement, pumping system	$ 2,800	
Maintenance	800	
Power	18,600	
Cedar Bluff Reservoir Share	1,200	$ 23,400

An amortization period of 50 years and a non-federal interest rate of 4 percent were used for converting capital costs to equivalent annual costs. Annual operation and maintenance was added to the annual cost. The annual value of storage for streamflow regulation for quality control is $137,000.

Figure VIII-3 shows the anticipated increase in requirements of storage for quality control purposes ranging from 420 acre-feet annually in 1970, when the proposed Round Mound Reservoir is expected to go into service, to 12,000 acre-feet annually by 2020. Draft on storage available from Round Mound Reservoir is expected to be 3,500 acre-feet annually and is the basis for the estimation of benefits attributable to quality control storage provided in this reservoir. Seepage from the reservoir was given a value when needed for quality control.

The quality improvement by this flow regulation will improve the raw water supply for Russell and will enhance Big Creek for municipal and industrial water supplies at the other municipalities in Big Creek, and also fishing, recreation, esthetics, and agriculture, including stock watering. Thus, the benefits would be widespread in scope.



ROUND MOUND STUDY AREA

SCHEMATIC DRAWING
OF
STUDY AREA

U.S. DEPARTMENT OF HEALTH, EDUCATION & WELFARE
PUBLIC HEALTH SERVICE
REGION VI KANSAS CITY, MISSOURI

Figure No. VIII-1

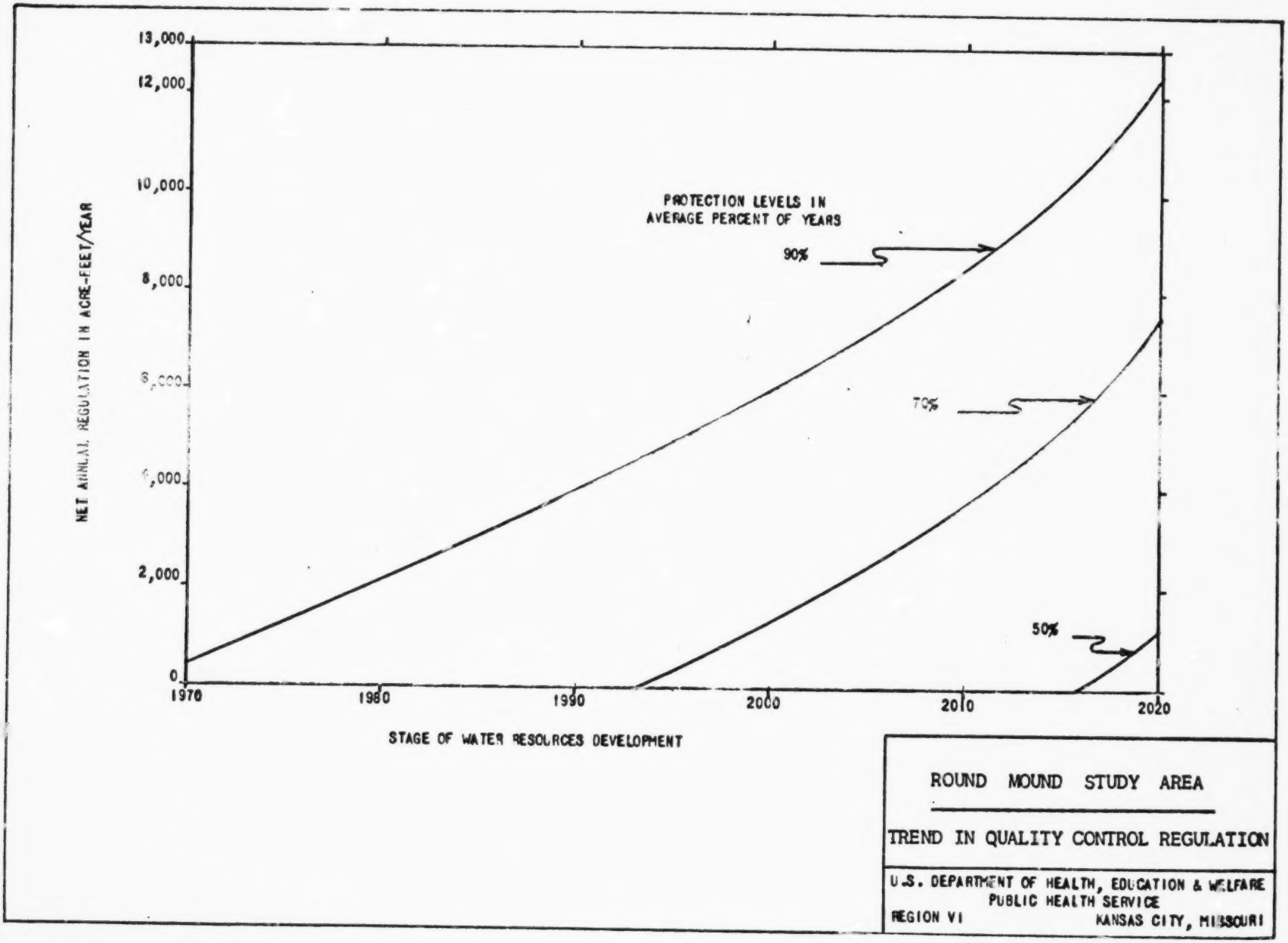


Figure No VIII-2

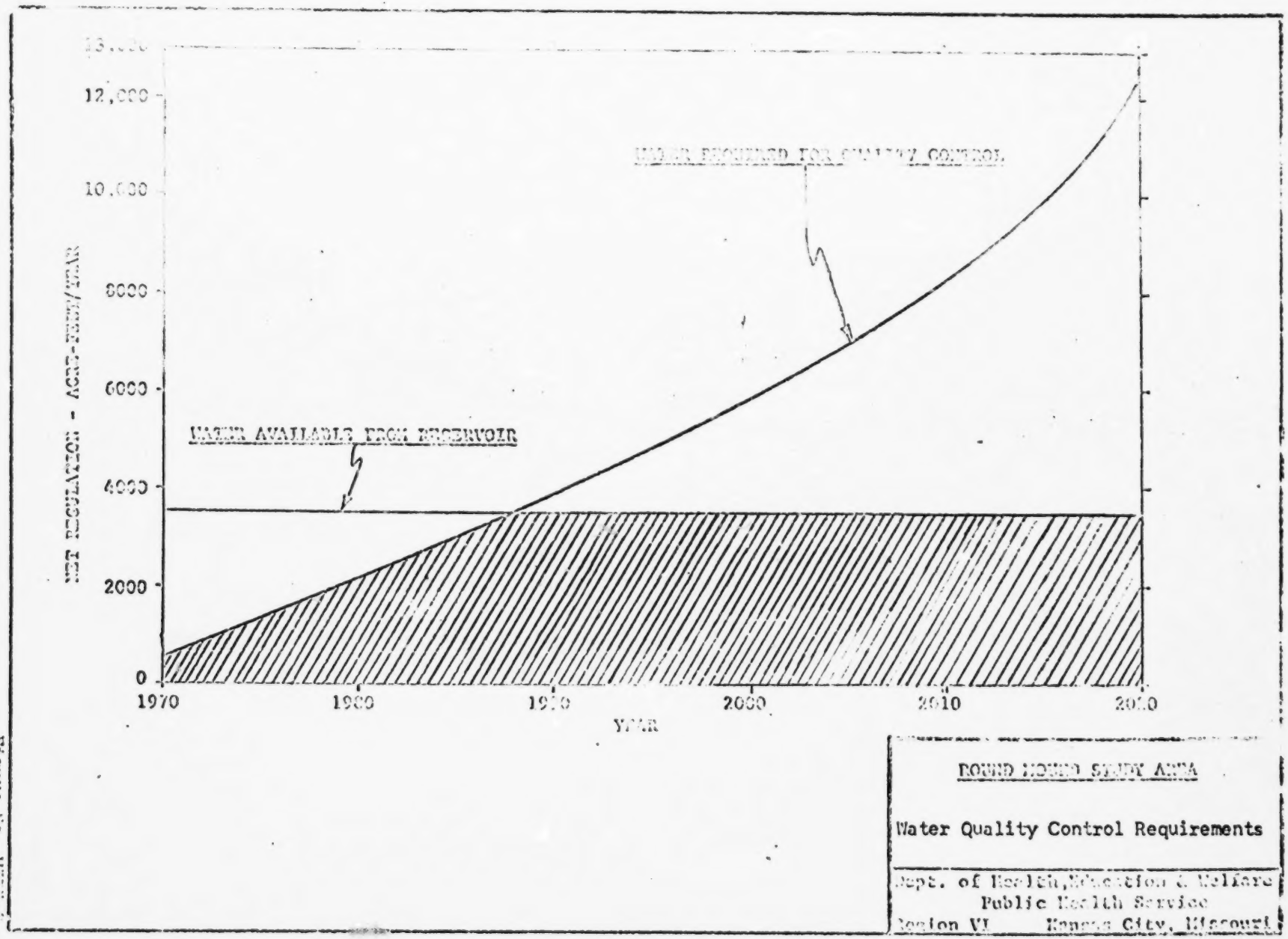


FIGURE NO. VIII-5

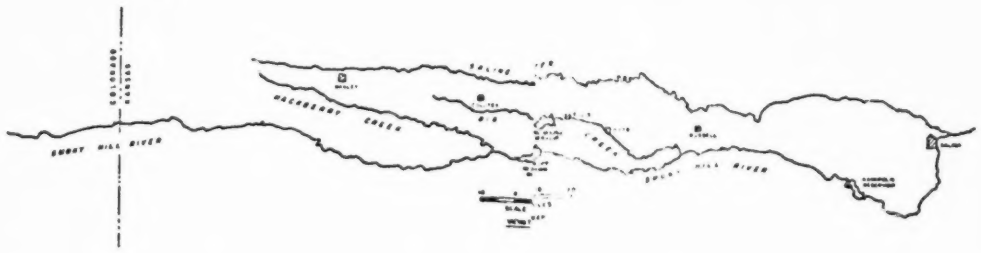
ROUND HOUSE CREEK AREA

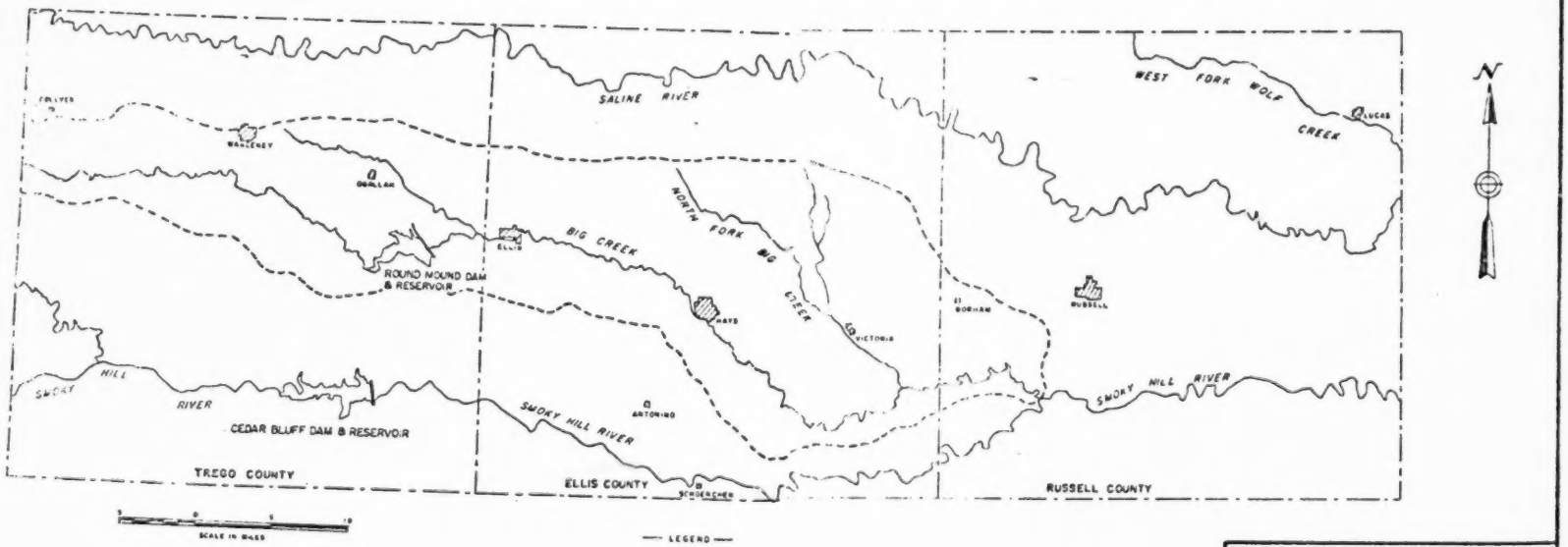
Water Quality Control Requirements

Dept. of Health, Education & Welfare
Public Health Service
Region VI Kansas City, Missouri

IX. MAP OF AREA

XIa



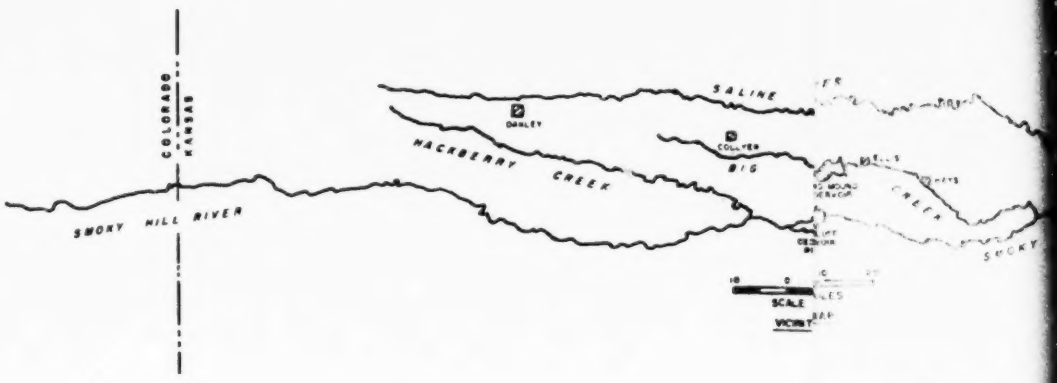


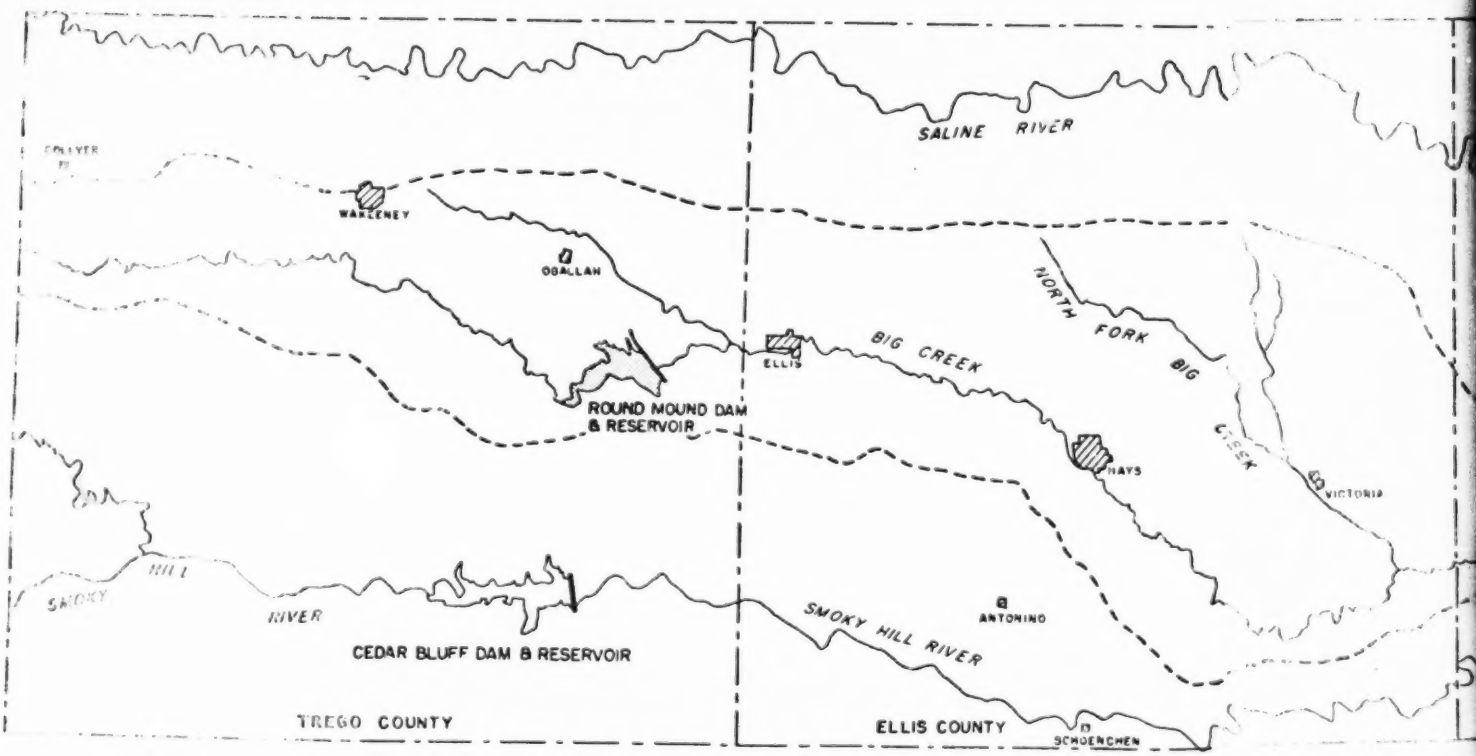
IX-16

ROUND MOUND

LOCATION MAP & STUDY AREA

U.S. DEPARTMENT OF HEALTH EDUCATION, & WELFARE
PUBLIC HEALTH SERVICE
REGION VI KANSAS CITY MISSOURI





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MUNICIPALITIES

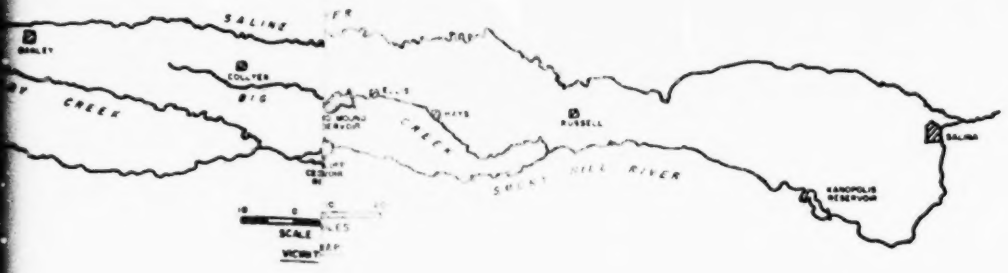
PROPOSED RESERVOIR

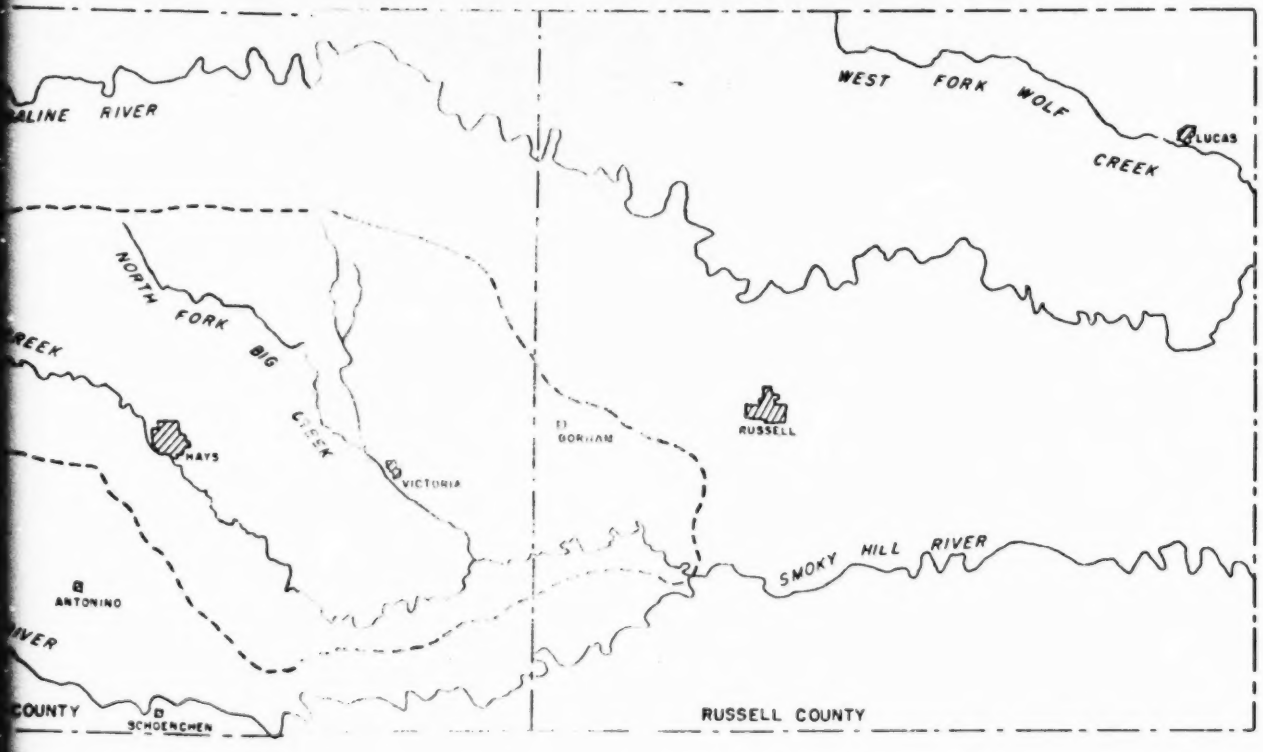
COUNTY LINE

BIG CREEK DRAINAGE BOUNDARY

IX-16

ARKANSAS CITY





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MUNICIPALITIES

PROPOSED RESERVOIR

COUNTY LINE

BIG CREEK DRAINAGE BOUNDARY

ROUND MOUND

LOCATION MAP & STUDY AREA

U.S. DEPARTMENT OF HEALTH, EDUCATION, & WELFARE
PUBLIC HEALTH SERVICE

REGION VI KANSAS CITY MISSOURI

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co/e/ar

XI. APPENDIX

Exhibit No. 1

Round Mound Study Area

Municipal Water Supplies

City	1960 Population	1963 Population Served	Water Treatment	Source of Supply	MGD* Maximum Draft	Average Plant Output MGD	GPCD
Collyer	233	200	Chlorination	Wells	0.08	0.02	100.0
Ellis	2,218	2,100	Chlorination	Wells (5)	0.35	0.20	95.2
Gorham	429	350	Chlorination	Wells	0.06	0.03	85.7
Hays	11,947	11,600	Softening, Iron Removal, Chlorination, Fluoridation	Wells (13)	3.71	1.30	112.0
Russell	6,113	6,200	Coagulation, Softening, Chlorination	Smoky Hill & Big Creek	1.2	0.60	96.7
Victoria	1,170	1,175	Chlorination	Wells (10)	0.30	0.15	127.6
Wakeeney	2,808	2,600	Chlorination	Wells (5)	1.25	0.40	153.8
		24,225				2.70	111.5

*Some maximum draft figures are approximate

Exhibit No. 1

Exhibit No. 2

Pound Mound Study Area

Typical Chemical Analyses of Water Resources
(Results in Parts per Million)

Location	Type*	Total Solids	Chlorides (Cl^-)	Sulfates ($SO_4^{=}$)	Nitrate (NO_3^-)	Hardness ($CaCO_3$)	Iron (Fe)	Remarks
Collyer	M-T	282	14.	9.0	13.0	230	0.02	Ground Source
Ellis	M-R	450	45.	68.	17.	317	0.01	Well #1
	M-T	749	93.	134.	13.	468	0.01	Tap
Gorham	M-R	867	152.	177.	53.	550	0.01	Well
Hays	M-R	582	26.	246.	1.5	399	4.3	Smoky Well #2
	M-T	361	66.	111.	19.	110	0.01	Tap
	M-R	501	42.	62.	24.	340	0.02	City Well #14
Russell	M-T	492	122.	129.	4.2	259.	0.01	Surface Source
Victoria	M-T	358	15.	28.	13.	272.	0.01	Surface Source
Wakeeney	M-T	309	10.	15.	1.9	257.	0.01	Tap
Big Creek near Ogallah	R	226	0.2	10.	1.1	168	-	Mean Q (cfs) = 234
Big Creek near Ogallah	R	261	9.5	20.	0.7	208	0.01	Mean Q (cfs) = 2.79
Big Creek near Ogallah	R	153	0.8	5.8	6.5	102	0.04	Discharge Weighted Avg. USGS

*M- Municipal
T- Treated water
R- Raw water

Exhibit No. 2

Exhibit No. 2 Continued

Round Mound Study Area

Typical Chemical Analyses of Water Resources
(Results in Parts per Million)

Location	Type	Total Solids	Chlorides (Cl^-)	Sulfates ($SO_4^=$)	Nitrate (NO_3^-)	Hardness ($CaCO_3$)	Iron (Fe)	Remarks
T. 11S, R 15W	Test	896	58	183	142	620	0.68	Pleistocene Source
T. 11S, R 15W	Test	629	40	49	257	280	3.4	Greenhorn Source
T. 12S, R 14W	Test	992	61	228	195	656	0.28	Alluvium Source
T. 12S, R 14W	Test	608	43	340	24	873	0.73	Alluvium Source
T. 12S, R 15W	Test	2,710	122	1,394	230	1,820	6.7	Tertiary Source
Victoria	M-R	5,535	2,610	550	9.7	270	5.2	Dakota Composite
T. 15S, R 15W	Test	949	131	71	261	498	0.62	Alluvium Source
T. 11S, R 18W	Test	1,008	92	157	252	431	89	Codell Source
T. 12S, R 17W	Test	291	10	7.9	14	262	6.3	" "

X-9

Exhibit No. 2 (2)

X1-3

Exhibit No. 3

Round Mound Study Area

Basic Data on Sources of Pollution

Municipality or Industry	River Miles above Mouth	1960 Population	(1963) Sewered Population	P.E.(BOD) before Treatment	Nature of Waste	Treatment Provided	P.E.(BOD) Discharged	Watercourse
Wakeeney	80.0	2,808	2,600	2,900E	Domestic	Secondary	600	Big Creek
Ellis	44.0	2,218	2,100E	2,100E	Domestic	Secondary	250E	Big Creek
Hays (South)	25.0	11,947	3,500	4,500	Domestic	Secondary	450E	Big Creek
Hays (East)	24.5		8,000	11,300	Domestic	Secondary	1,950E	Trib. to Big Creek
Victoria	13.5-7	1,170	1,000	1,000E	Domestic	Tertiary	100E	Branch N. Fork Big Creek
Gorham	10-6	429	400E	400E	Domestic	Lagoon	60E	Dry Trib. of Walker Creek
Russell	4.5	6,113	6,100	6,500E	Domestic & Industrial	Secondary	920E	Fossil Creek
			23,700				4,330	

Exhibit No. 3

Exhibit No. 4

Round Mound Study Area

A Sample Distribution of Monthly Mean Reservoir Releases Needed for Quality Control, in MGD, Above Seepage*

Month	1970	1995	2020
(4) April	0	2	10
(5) May	0	0	10
(6) June	1	12	27
(7) July	2	13	27
(8) August	2	13	27
(9) September	3	14	27
(10) October	0	2	10
(11) November	0	1	6
(12) December	0	2	6
(1) January	0	2	6
(2) February	0	2	6
(3) March	0	1	6

*Volumes contain 20% average to cover such items as conveyance losses and a typical flow or quality condition. This is not an operating schedule.